Space Weather Technical Forecast

Issued on Monday, 20 December 2021 at 13:25 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of G1/Minor Storms day 2 (21st). Slight chance of M-flares throughout. Chance of Active electron fluence developing later in the period.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar Activity has been Moderate over the past 24 hours, with a number of C-class X-ray flares observed, and one M1.9 flare at 20/1136 UTC. There are currently seven numbered sunspot regions and one further unnumbered region on the Earth facing disc. The most prominent is a series of three regions in the southern central disc. AR2907 remains the most complex, although this region has shown some decay over the past 6 hours with the leading spots penumbra fading, and it is now classified Cai/Beta-Gamma. AR2908 was the likely source for the M-class flare, but this too has shown some decay and is currently classified Cao/Beta. AR2909 also decayed, after a C4.1 flare at 20/0323 UTC, it is classified Cso/Beta. All other regions are either small unipolar or bipolar regions, with limited flare risk, but situated within areas of plage, giving the potential for further development. No Earth-directed CMEs have been observed in available imagery.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by the DSCOVR satellite at L1, rose since 19/1210 UTC from background levels of around 350km/s to become elevated at 520-560 km/s from 20/0110 UTC. Density has generally been average or slightly above average between 9 and 16 ppcc, but a period of above average values were observed until 19/1800 UTC, with a peak of 52 ppcc at 19/1735 UTC. The Interplanetary Magnetic Field Strength (IMF), Bt also rose from moderate values near 10nT, to peak at 24nT at 19/2035 UTC. This was associated with Bz also strengthening but becoming variable, ranging +15nT to -20nT, with peak southward (negative) component at 19/2038 UTC. Since 20/0110 UTC the field strength has been weak (5-8 nT). The phi angle was predominately negative throughout (towards the Sun). These parameters were the result of a strong CIR region arriving ahead of the transition into the fast wind of coronal hole 36 (CH36). Geomagnetic activity has been Quiet to Active (Kp 2-4), with a G1/Minor Storm interval recorded 19/2100-2400 UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) remained at Background levels. The high energy electron flux (greater than 2 MeV) was at mainly Background levels, but peaked at moderate during the diurnal maximum. The associated 24-hour integrated fluence remained well below the Active threshold and stable. A fluence of 4.87e6 was observed at 20/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be predominantly Low, with further C-class flares and a slight chance (20%) of isolated M-class flares, mainly from AR2907, AR2908 and AR2909, but they cannot be ruled out from the other sunspot regions on the disc given further development. There are also a number of filaments visible in H-alpha imagery and whilst currently stable, they will need monitoring for any potential lift.

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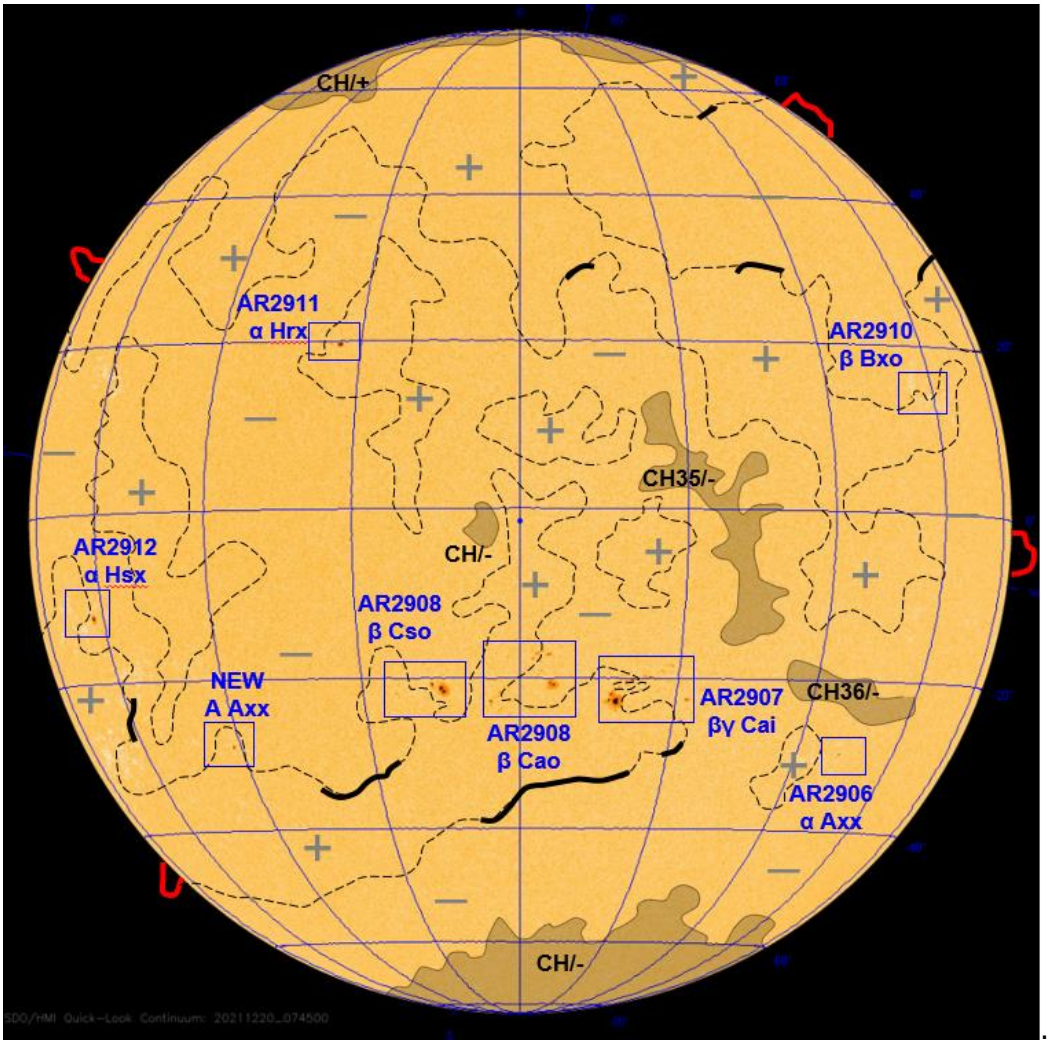
Solar Wind / Geomagnetic Activity: There are currently no Earth-directed CMEs in the forecast. Elevated solar winds are expected to persist through days 1-3 (20th-22nd) due to CH36 and then CH35, before gradually easing on Day 4 (23rd). Geomagnetic activity is forecast to be Quiet to Unsettled through days 1-3 (20th-22nd), with Active intervals possible. These are most likely to occur early on day 2 (21st) during the transition to CH35, when there is a chance of a G1 / Minor Storm. On day 4 (23rd), geomagnetic activity is likely to become mostly Quiet.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels and below the S1 level, although there is the potential for some increased flux from any flare activity. The high energy electron flux is forecast to be at background at first, but rising days 1-3 (20th-22nd) due to recent solar wind enhancements from the arrival of the fast wind of CH36. Peak flux is likely to reach High levels (1000 pfu), but brief some drop outs are possible as any further enhancement from CH35 arrives. Persistently high flux is possible by day 4 (23rd). The associated 24 hour fluence is expected to remain below the Active (1e8 integrated pfu) threshold until at least day 2 (21st) with a chance of then rising above. Whilst this risk increases through the period, it remains low confidence.

Figure 1. Solar Analysis Valid 20/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

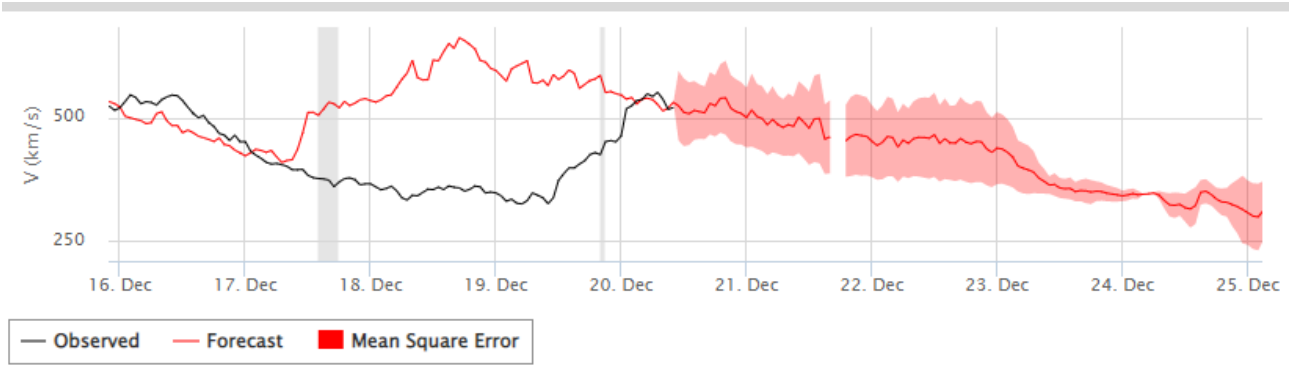
There are currently no Earth-directed CMEs in the forecast. Earth is connected the fast wind of CH36, with solar winds currently elevated around 550 km/s. Solar winds are likely to remain elevated through days 1-3 (20th-22nd), with further enhancement coming from CH35. A gradual decline is then expected on day 4 (23rd) as coronal hole effects wane. This is supported by enlil and 27-day persistence which shows a fast wind enhancement until day 3 (22nd), and then easing.
Geomagnetic activity is forecast to be Quiet to Unsettled through days 1-3 (20th-22nd), with Active intervals possible. These are most likely to occur early on day 2 (21st) during the transition to CH35, when there is a chance of a G1 / Minor Storm. On day 4 (23rd), geomagnetic activity is likely to become mostly Quiet.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	10	30	10	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil.

Figure 2 MOSWOC Solar Wind Persistence Model (SWPM):



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Radio Blackouts - X-Ray Flares:

There are currently eight active sunspot regions on the Earth-facing disc, however most of these are small and simple. The exception to this are three regions close to centre disc in the southern hemisphere, with AR2908 producing an M1.9 flare at 20/1136 UTC, AR2909 a C4.1 flare at 20/0323 UTC and AR2907 a C3.8 at 19/2112UTC. Despite this, all these regions have shown some form of decay over the past 24 hours. AR2911 Cso/Beta in the northeast, was the source of an M-flare on the 17th, but has simplified to become a unipolar region.
With all regions either small, or showing signs of decrease, solar activity is forecast to be predominantly Low, with further C-flares expected. There is a slight chance (20%) of isolated M-class flares throughout the forecast.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	20	20	20	20
Very Active	R3 to R5 X Class	No	2	2	2	2

Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is currently at Background levels.
Despite the large number of sunspots on the disc, a number of which are now moving into an improved geoeffective location for radiation storms, their small size and generally simple magnetic structure means that proton rich flaring is unlikely. Background levels are expected to persist, with a chance of some small increases from any notable flares that do occur. However, there is only a very slightly above background risk of rising to the S1 alert level.

Radiation Storms	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	2	2	5	5
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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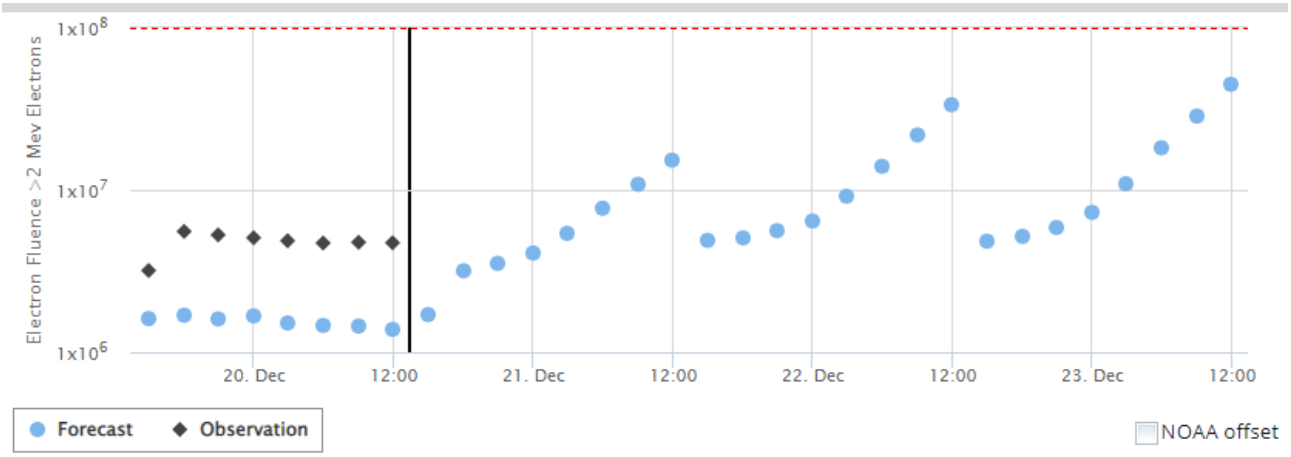
High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux as observed by GOES-16 is currently at background, but likely to increase as a result of recent fast wind enhancements from coronal hole 36. Once early geomagnetic activity on day 1 (20th) eases a gradual build of observed flux is likely, peaking at High levels (above 1000 pfu). Further enhancement from any arrival of fast wind from CH35 on day 2 and 3 could bring dropouts to the observed flux, before Moderate to High levels are expected to resume. This enhancement is currently uncertain however, giving low confidence to the forecast by day 3 and 4 (22nd and 23rd).
The associated 24 hour fluence is expected to remain below the Active (1e8 integrated pfu) threshold until at least day 2 (21st) with a chance of then rising above. Whilst this risk increases through the period, it remains low confidence due to uncertainty around the strength of any enhancement from CH35. REFM is giving good guidance showing a rising trend for the current solar wind enhancement.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	5	30	30	40
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 3: Observed electron fluence from GOES-16 and REFM forecast data.



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